Wax

UNIVERSITY OF HAWAII

THE ALOHA SYSTEM

MEMORANDUM

TO: Franklin F. Kuo
Norman Abramson

FROM: Dave Wax

SUBJECT: Report on Packet Radio Group Meeting, 8-9 November 1973

DATE: November 20, 1973

The writer attended a meeting of the Packet Radio Group held at Collins Radio Company, Dallas, Texas, on November 8 and 9, 1973. Attending the meeting were representatives from ARPA, BBN, NAC, SRI, UCLA, Collins, and University of Hawaii. The meeting was chaired by Bob Kahn of ARPA.

Dr. Kahn opened the meeting with the announcement that ARPA's application for frequency allocations had been approved by the Navy and that they may use the 350-450 MHZ and 1300-1400 MHZ bands in Dallas and San Francisco until April 30, 1975. He also indicated that the experimental system will operate initially with standard data terminals since he does not expect any hand-held terminals to be available until 1975. He then presented the following agenda for the meeting:

1) Collins will describe the status of the test set.
2) SRI will review their plans for testing, using the Collins test set.
3) Documentation will be discussed.
4) Microprocessors will be reviewed.
5) Proposals for the logic design of a baseline system will be presented and examined.
6) NAC will present their results on simulation and routing studies.
7) UCLA will discuss their study of the hidden terminal problem.
8) SRI will present their most recent notes.
9) University of Hawaii will present status of repeater implementation.

All of the above subjects were covered in the course of the meeting, although not exactly in the order indicated.

The first subject discussed was documentation. Dr. Kahn indicated that it was yet too early to put out formal publications. However some information on a baseline system could be published. He indicated his feeling that it is too early to get into technical details of the packet radio network. He indicated as a ground rule that permanent packet radio notes will be available to people who request them. This means that we give these notes out on request. But he does not want to get into a full-scale publication effort at this time. The question came up of a packet radio session in connection with the National Computer Conference in May. Dr. Kahn indicated he would explore this possibility, but indicated his concern over whether there is enough time to get papers ready.

Collins then presented a summary of its work on the radio propagation test set designed and built to SRI's requirements. The technical details of the test set are contained in a document handed out at the meeting, a copy of which I have. Basically the test set consists of a separate transmitter and receiver using a bi-phase modulated spread spectrum signal. The transmitter can generate a 127-chip spread spectrum signal at either a 10 or 20 mega-chip rate. Two transmit frequencies are available, one at 430 MHZ and the other at 1325 MHZ. These signals may be generated simultaneously with nominal power outputs of 10 watts at 430 MHZ and 5 watts at 1325 MHZ. The system can operate in either a CW mode or spread spectrum mode, depending on types of measurements to be made. The receiver can receive either of the two transmitted frequencies, but not simultaneously. It has a wideband mode (about 50MHZ), narrowband mode (about 500 KHZ), and a doppler mode (about 100 HZ). Detection of the spread spectrum signal is accomplished using 127 chip code correlators followed by envelope detectors. The correlators were Surface Acoustic Wave Devices (SAWD's). The receivers are also configured for noise measurements of both peak and average noise levels. Six threshold detectors will simultaneously detect signal levels at 10 db intervals. Details are contained in the Collins publication which I have. Following the introductory presentation on the test set, members of the group were taken to a Collins testing lab to look at the equipment. A demonstration of transmission of the spread spectrum signal was provided. Multipath due to in-building reflections could be observed.

Following the Collins presentation, Stan Fralick of SRI introduced the SRI presentation. He indicated the two primary activities of SRI as propagation measurements (using the Collins test set) and development of a Packet Radio Channel Test Facility. A third activity is the development of an overall system design of a baseline system. Don Nielson of SRI then presented the propagation measurement program, which will be published as a permanent packet radio note. The program consists of measurement of noise and propagation. Noise characteristics of interest are:

- Joint density of both noise impulse amplitude and width
- Density of pulse interval
- Density of peak amplitude
- Amplitude probability density
- Average noise power
- Ratio of RMS to average noise voltage

Propagation characteristics of interest are:

Wideband:

- Distribution of maximum time-delay
- Time-delay spread
- Resolvable pulses versus amplitude
- Time interval between pulses
- Ratio of RMS to average power

Narrowband:

- Power spectral density (fixed receiver)
- Power spectral density (moving receiver)

Received pulses will be sampled at 100 megasamples/sec., the samples digitized, and processed in an accompanying digital computer. The receiver and digital processing equipment will be contained within a mobile van which has been obtained by SRI and is now being equipped. The transmitter will be located at selected fixed sites in the San Francisco area. It will have dual omni-directional antenna consisting of a low-gain dipole for 430 MHZ and a 7.5 dbi gain stacked colinear array for 1325 MHZ. An additional antenna is also available for the transmitter consisting of two low-gain dipoles one for each frequency. The test van will have a dual low-gain pair of dipoles mounted on its roof. Measurements will be initiated in December 1973, and should be completed by the end of February 1974.

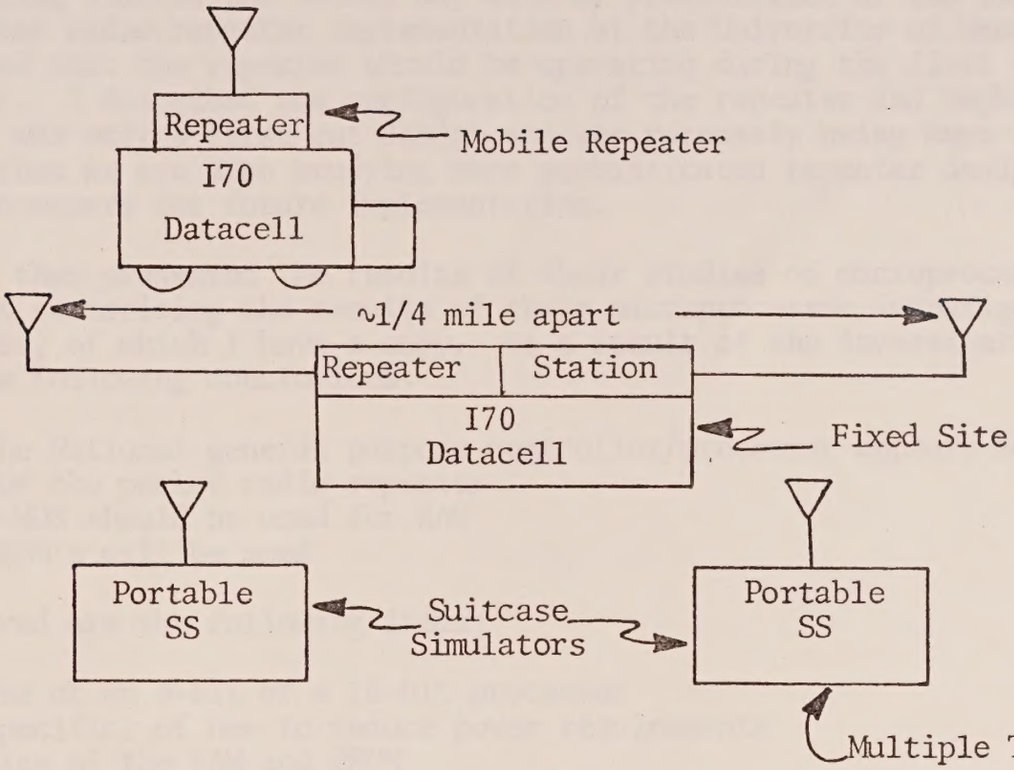
Dave Brandin of SRI then presented their development plans for the Packet Radio Channel Test Facility. This information may be found in PRTN #77. This facility has as its objectives (in addition to studying the propagation and noise characteristics of the channel):

- Validation of the analytical models of the channel
- Verification of simulation results
- Providing a simulation vehicle for testing design concepts

To meet these objectives, the test facility will be designed to support the following experiments:

- Bit error rate and packet error rate
- Channel loading
- Interference effects
- Detectability
- Capture effect

The initial hardware configuration presently visualized to implement the above experiments will consist of a mobile repeater (to be built by Collins and available by summer 1974), a fixed repeater, a station, and two portable suitcase simulators. The arrangement is shown as follows:



One of the suitcase simulators will be used to create large amounts of traffic in order to stress the channel. A functional description of the suitcase simulator was presented and is shown as Figure 1 of PRTN #77. Total estimated cost of components was estimated as $3600 plus cost of modem and radio.

Following SRI's presentation, NAC presented results of simulation studies of the non-slotted, carrier sense access mode model presented by Fralick and Leung in PRTN #51. Modifications of the network model were made in the course of simulation studies to improve network throughput. The results presented were for a network with an acknowledgement scheme using two acknowledgements: an end-to-end ack and a repeater echo ack. Maximum handover numbers were also incorporated. Packets from the station to terminals moved much more readily than packets from the terminals into the station. The primary bottleneck appears at the repeaters interfacing into the station. I did not get a copy of the simulation results, but they should be available from NAC.

UCLA then presented their note on carrier sense with hidden terminals (PRTN #75). The presentation was given by Tobagi and closely followed the note. The main result of their study was that the performance of carrier sense (throughput-wise) was badly degraded by the existence of hidden terminals. They plan to investigate the "busy tone" access mode as a good candidate to solve the hidden terminal problem.

Bob Kahn discussed the consolidation of Packet Radio Temporary Notes. He emphasized the importance of completing this task as soon as possible. When submitting the consolidated permanent notes, mark them as DRAFT.

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The meeting started the second day with my presentation of the status of the packet radio repeater implementation at the University of Hawaii. I indicated that the repeater should be operating during the first week of December. I described the configuration of the repeater and emphasized that it was only a first cut design and was purposely being kept simple. I told them we are also studying more sophisticated repeater designs using microprocessors for future implementation.

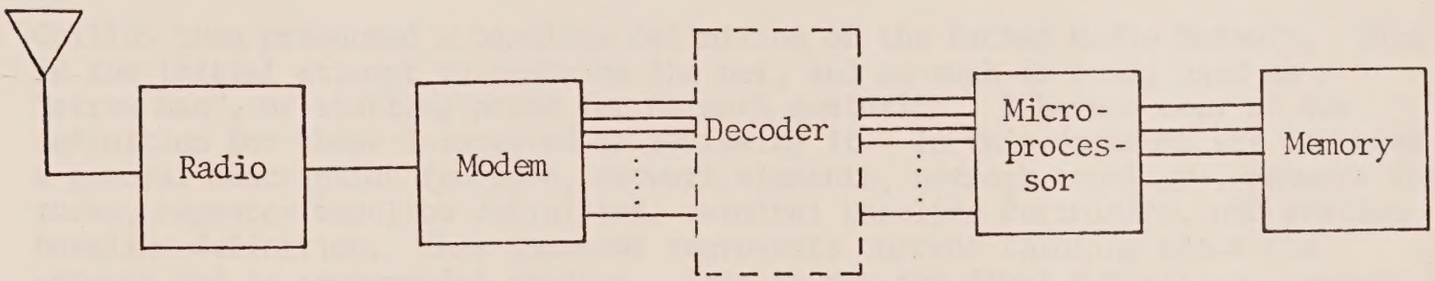
Collins then presented the results of their studies of microprocessors. A document summarizing the results of their microprocessor investigations was presented, of which I have a copy. As a result of the investigations, they made the following conclusions:

- The National general purpose controller/processor appears most promising for the packet radio repeater
- C-MOS should be used for RAM
- PROM's will be used

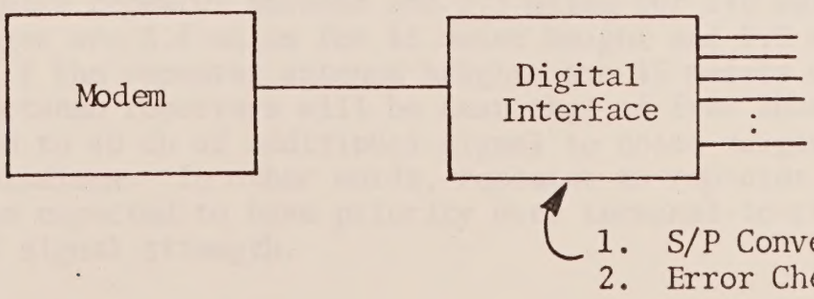
Unresolved are the following items:

- Use of an 8-bit or a 16-bit processor
- Specifics of how to reduce power requirements
- Size of the RAM and PROM

Kahn expressed his feeling that higher speed need not take precedence over power requirements, all other factors taken into consideration. He indicated his idea of the repeater's data structure as follows:



Collins' idea was similar except that the S/P conversion was contained within a universal digital interface:



A. K. Jain of Collins then presented his PRTN #73-76. He discussed the selection of 127 chip maximal length code for the test set (Note 73). The code was selected for minimum sidelobes of the autocorrelation function in order to optimize the peak to sidelobe level. In note 76, he documents the results of an investigation undertaken to study the effects of the channel filters on the theoretical performance of a matched filter SAWD in terms of the degradation of its autocorrelation peak and side lobes. A result of the analysis shows that a set of channel filters similar to those used in the test set can reduce the ratio of autocorrelation peak to maximum sidelobe from 24 db to 19.8 db. Based on this result, Collins is going to strongly consider the use of MSK (Minimum Shift Keying) which has the advantages of constant amplitude and minimum phase shift.

At this point Bob Kahn presented a technique he proposed for modem signalling which could drastically decrease the amount of sidelobe interference at the output of a matched filter due to overlapping signals. The approach is described in a preliminary draft of a PRTN, of which I have a copy. Instead of sending a single spread spectrum signal, he considers sending two signals in separate frequency bands, simultaneously. If one spread spectrum signal has a main lobe essentially the same as the other one, and sidelobes opposite in sign, then upon reception the two detected signals can be summed together to cancel the sidelobes and enhance the mainlobe. The practical problems of implementing such a scheme are not yet known, but there was a general feeling that it should be investigated. It will not be easy to implement. Bob Kahn pointed out that one way to approximate such a pair of signals is by using complementary codes.

Collins then presented a baseline definition of the Packet Radio Network. This is the initial attempt to describe the net, and as such is being used as a "straw man", or starting point for network evolution. I have a copy of the definition for those interested in reviewing it. In this document are included a general description (purpose, network elements, network topology), network features, repeater baseline definition, terminal baseline definition, and station baseline definition. This document represents current thinking about the network and is recommended reading. This is not the final definition; however Bob Kahn expects the baseline document to be finished in time for the January 1974, Packet Radio Group meeting. In addition to the baseline definition, another document was presented which is a preliminary range analysis of the baseline definition. Okumura's path loss curves are used in this preliminary analysis and only Gaussian noise is considered. Calculations indicated for 1317 MHZ an approximate maximum distance from repeater to terminal of 2.3 miles for a 45 meter high repeater antenna and 3.3 miles for 140 meter height. At 453 MHZ the ranges are 3.4 miles for 45 meter height and 9.2 miles for 140 meter height. If the repeater antenna heights are 45 meters or higher, then the path loss between repeaters will be near that of free space attenuation, which implies 20 to 40 db of additional signal to noise margin over repeater-to-terminal transmissions. In other words, repeater-to-repeater transmissions can almost always be expected to have priority over terminal-to-repeater transmissions on the basis of signal strength.

Following the Collins presentation, Bob Kahn presented his note (No. 80) on A Protocol for Internetwork Packet Communication. This document describes an internetwork protocol which provides for variation in individual network packet sizes, transmission failures, sequencing, flow control, end-to-end error checking, and the creation and destruction of logical process-to-process connections. I have a copy for anyone interested in reading it. This PRTN should be in distribution and some people may already have it.

To finish up the meeting, Bob Kahn presented an overall program plan, or goals for network implementation. The following items were presented:

- Collins will have the first repeater built by the summer of 1974
- The baseline system document should be finished by the January 1974 meeting
- SRI should have its Bay Area measurement experiments completed by the end of February 1974
- During the period of summer 1974 to summer 1975, the number of repeaters in the experimental packet radio network should be increased from one to three or four. Also, the number of terminals should be increased from two to six
- The first station should be operational by the end of 1974. However, it will not be relied upon until mid-1975
- A hand-held terminal will not be considered available until late in 1975, at the earliest. This is a deferred item; the keyboard and display are still under study

DW:ek
cc: All Task I Personnel